Introduction to Botany. Lecture 35

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Outline

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Previous final question: the answer

What are microphylls?

Previous final question: the answer

What are microphylls?

- Leaves-emergencies
- Leaves of lycopods

Pteridophyta classes

	1	2	3	4	5	6	7	8	9	10
Lycopodiopsida	1	0	0	1	0	0	1	1	0	0
Equisetopsida	0	1	0	1	0	1	0	1	0	1
Psilotopsida	0	1	1	0	0	0	0	0	0	1
Ophioglossopsida	0	1	0	0	0	0	1	0	0	0
Marattiopsida	0	1	1	0	0	1	0	1	1	0
Pteridopsida	1	1	0	0	1	1	0	1	1	0

1 Big (> 1,000 species); 2 Megaphyllous; 3 Synangia; 4 Strobilus; 5 Leptosporangia; 6 Terrestrial gametophyte; 7 Biflagellate sperm; 8 Roots; 9 Fronds; 10 Reduced leaves (enatia and scales). Characters are not necessary relevant to all members of class.

Spermatophyta, seed plants

Classes of seed plants

Spermatophyta: seed plants

- $\approx$ 600 species of non-angiosperms and $\approx 250,000$ species of angiosperms
- Sporic life cycle with sporophyte predominance and **seed**
- Gametophyte is reduced to cells inside ovule or inside pollen grain. Minimum number of cells is 3 for male gametophyte (pollen grain) and 4 for female gametophyte (embryo sac of angiosperms). Anteridia are reduced. In angiosperms and Gnetopsida, archegonia are also reduced.
- Sporophyte always starts development from embryo located inside nutrition tissue, endosperm$_1$ (female gametophyte) or endosperm$_2$ (second embryo)
- Have axillary buds
- Homoiohydric plants (same as ferns)
- Have secondary thickening

Spermatophyta classes

- **Ginkgoopsida**, ginkgo class
- **Cycadopsida**, cycads
- **Pinopsida**, conifers
- **Gnetopsida**, gnetophytes or chlamydosperms
- **Angiospermae**, or Magnoliopsida, flowering plants

Ginkgoopsida

- Smallest class, only one species (!), Chinese tree *Gigkgo biloba* which became extinct several thousand years ago but saved as a ”church tree”.
- Distinctive triangle-shaped leaves with dichotomous venation
- Ovules are solitary or paired; microsporangia are in catkin-like structures; has sexual chromosomes (!)
- Pollen grains produce two mutli-flagellate spermatozoa which swim to large oocyte
- Seeds are fruit-like (generally edible), become ripe laying on a ground for a long time
- Almost no phytophagous insects damage *Ginkgo* leaves; the fungal symbiont of *Ginkgo* also belongs to separate class inside basidiomycetes, Bartheletiomycetes.

Ginkgo biloba ovules

Ginkgo biloba male organs

Ginkgo biloba seeds

Cycadopsida

- Two families, dozen genera and $\approx$ 300 species distributed mostly in tropics
- Palm-like plants, with large (and usually very rigid) pinnate leaves
- Stem structure is not similar to conifers and *Ginkgo*; cycads have large pith and anomalous secondary thickening via multiple cambium rings
- Ovules are attached to modified leaves (sporophylls) and usually gathered in large upright cones; microsporangia are always in cones
- Also have multi-flagellate spermatozoa, archegonia and large oocyte
- Large seeds are animal-distributed; life cycle is extremely slow (several years from initiation of cone to germination of seed).

Cycadopsida families

- Two families, sometimes even placed in different orders:
  - **Cycadaceae**, whith only genus *Cycas*. They do not have female cones, ovules are attached to leaves which are not radically modified. Leaves have fiddleheads (same in ferns!).
  - **Zamiaceae**, with all other genera (*Zamia integrifolia* is native to USA). Have female cones.

Cycas sp.: young leaflets form fiddleheads

Male *Cycas* sp. in dry season

Cycas sp. seeds

Encephalartos gratus (Zamiaceae)

Zamia integrifolia (Zamiaceae)

Spermatophyta, seed plants

Conifers

Pinopsida

- Three orders, several families and $\approx$ 600 species
- Mostly temperate evergreen trees, but some are deciduous (like *Larix*, *Pseudolarix*, and part of Cupressaceae)
- Stem with large amount of xylem, relatively small cork and minute pith
- Ovules are always attached to specialized leaves (seed scales) and together with bract scales they are compacted in cones; microsporangia are attached to microsporophylls and also occur in cones of simpler structure
- Male gametes without flagella (spermatia), consequently, pollen grains grow into **pollen tubes**
- Female gametophyte is more reduced than in cycads and *Ginkgo*
- Seeds are wind- and animal-distributed, life cycle shorter but still up to two years

Pinopsida orders and families

- Pinales
  - **Pinaceae**.
- Araucariales—grow mostly in tropics or in South Hemisphere.
  - Araucariaceae
  - Podocarpaceae
- Cupressales
  - Sciadopityaceae
  - **Cupressaceae** (incl. Taxodiaceae)
  - Cephalotaxaceae
  - **Taxaceae**

Pinaceae

- Have resin and needle-like leaves, often in shortened shoots, **brachyblasts**. Large cones with paired (seed and bract) scales.
- Biggest conifer family, include large genus *Pinus* (pine) and other genera like *Larix* (larch), *Cedrus* (cedar), *Picea* (spruce), *Abies* (fir) etc.

Cupressaceae and Taxaceae

- **Cupressaceae**—cypress family. No resin. Cones are small, with fused bract and seed scales. Leaves are dimorphic, needle-like and scale-like. Part of genera (formerly belong to Taxaceae family) are deciduous but with branches instead of leaves. Genera: *Cupressus* (cypress), *Juniperus* (juniper), *Taxodium* (bald cypress), *Sequoia* (coastal red cedar), *Sequoiadendron* (mountain red cedar), *Metasequoia* etc.
- **Taxaceae**—yew family. Female cones are modified in berry-like structures with one enlarged red scale. Leaves are needle-like. No resin. *Taxus* (yew) provides famous reddish-brown, springy wood.

Pseudolarix amabilis (Pinaceae), spring

Sequoia sempervirens (Cupressaceae)

Taxus baccata, Taxaceae

Spermatophyta, seed plants

Gnetophytes

Gnetopsida

- Small class of only three genera (*Ephedra*, *Welwitschia*, *Gnetum*), which are so different that botanists place them in different orders (and sometimes even subclasses).
- Tropical trees (*Gnetum*) or desert shrubs (*Ephedra*) or nobody-knows-what (*Welwitschia*)
- Stem structure is similar to conifers but *Gnetum* and *Welwitschia* have vessels (like angiosperms)
- Ovules are solitary, **covered with additional outer integument** (however, **this is not a pistil** because micropyle come out of this cover)
- Male gametes are spermatia, have pollen tube and **no archegonia** in *Gnetum* and *Welwitschia* (like in angiosperms). Multiple fertilization an polyembryony is widespread, *Ephedra* even has a double fertilizarion (like angiosperms). Only one embryo survives, other are eaten ($endosperm_2$). Also have $endosperm_1$ (female gametophyte).
- *Welwitschia* is insect-pollinated, other are wind-pollinated like most non-angiosperms.
- Seeds are animal-dispersed (except *Welwitschia*).
- Amazingly, molecular data show relations with conifers, not with angiosperms!

Gnetum

- Tropical shrubs, vines or small trees (30–35 species) with opposite leaves with pterodromous venation (like angiosperms again!). However, investigation of leaf development showed that initially leaf had dichotomous venation (like *Ginkgo* and some conifers).
- Dioecious plants, male and female structures (fructifications) are catkin-like
- Seeds big, colored

Gnetum seeds

Gnetum female fructifications

Gnetum male fructifications

Welwitschia

- One species occurring in Namibian desert (South Africa)
- Life form is completely unusual, the best description is “overgrown seedling”: small trunk with only two (constantly growing on the basement and degrading on top) wide leaves with parallelodromous venation. Secondary thickening anomalous (like in cycads). Wood with vessels.
- Insect-pollinated (!) dioecius plants
- Fructifications are cone-like; male one is similar to flower and contain sterile ovule (!)
- Seeds are wind-dispersed

Welwitschia

Welwitschia

Welwitschia female cones

Welwitchia male cones

Welwitchia pollinators: *Odontopus sexpunctulatus* bug

Ephedra

- $\approx$ 35 species growing in dry places across all North Hemisphere and also in South America
- Shrubs or small trees, leaves are usually reduced to scales, stems are articulate (like horsetails). Wood is similar to conifers.
- Plants are monoecoius or dioecious, male and female (bisexual also occur) fructifications are short, covered with thick scales
- Wind-pollinated, animal dispersed
- *Ephedra sinensis* is a source of pharmaceutically important **ephedrine**
- In all, *Ephedra* is more primitive than two other genera of Gnetopsida: wood does not contain vessels, ovule has large archegonia

Ephedra

Ephedra nevadensis, female fructification

Ephedra nevadensis, male fructification

Ephedra seeds

Spermatophyta classes (and genera)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Ginkgoopsida	0	0	1	0	0	0	1	1	0	1	0	0	0
Cycadopsida	1	0	0	0	1	0	1	1	0	1	0	1	0
Pinopsida	0	1	1	0	1	0	0	1	0	1	0	0	1
Gnetum	1	0	1	1	0	0	0	0	0	1	1	0	0
Welwitschia	1	0	0	1	1	1	0	0	0	1	1	1	1
Ephedra	0	1	1	0	0	1	0	1	1	1	1	0	0
Angiospermae	1	0	0	1	0	1	0	0	1	0	1	1	1

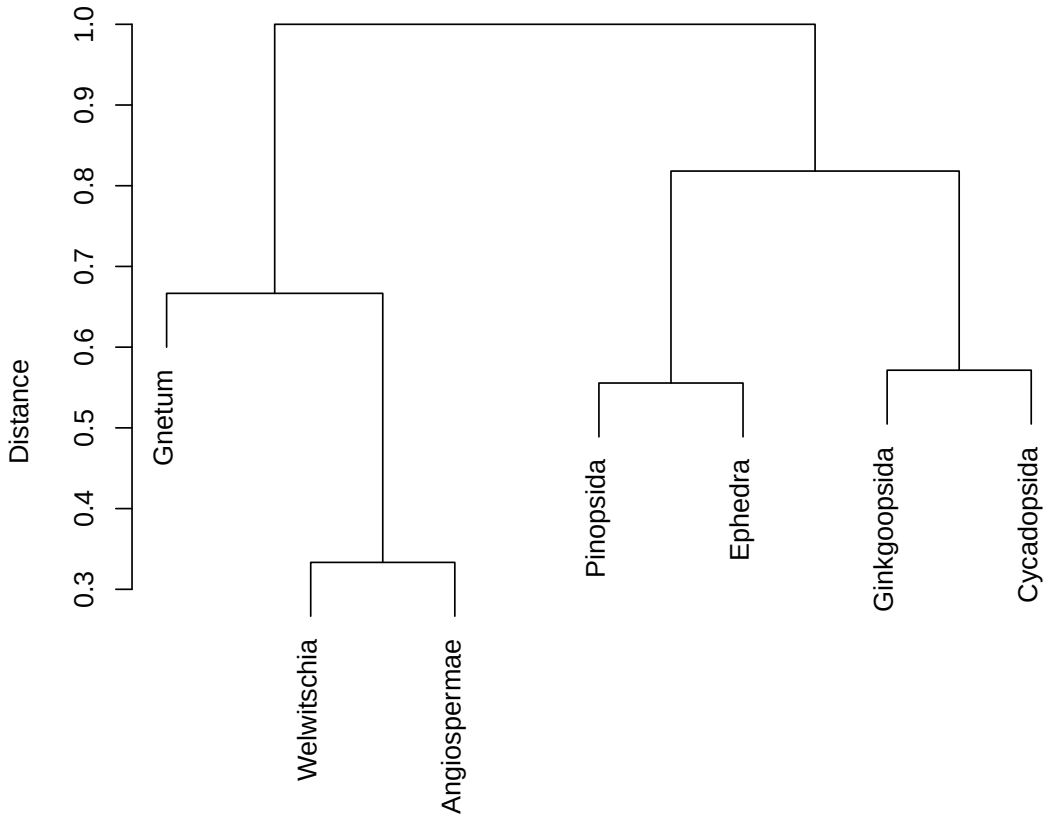
1 Tropical; 2 Leaves needle- or scale-like; 3 Coniferous wood; 4 Vessels; 5 Cones; 6 Bisexual fructifications; 7 Flagellate sperm (and micropylar chamber, and no pollen tube); 8 Archegonia; 9 Double fertilization; 10 Endosperm$_1$; 11 Endosperm $_2$; 12 Insect pollination; 13 Wind seed dispersion.

Characters are not necessary relevant to all members of class. Angiosperms characters taken from most primitive members (Magnoliidae subclass).

Make the dendrogram 1: table of dissimilarity

	Ginkgoopsida	Cycadopsida	Pinopsida	Gnetum	Welwitschia	Ephedra
Cycadopsida	0.5714286					
Pinopsida	0.5714286	0.6666667				
Gnetum	0.7142857	0.7777778	0.7777778			
Welwitschia	0.9090909	0.6000000	0.7272727	0.5555556		
Ephedra	0.6250000	0.8181818	0.5555556	0.6666667	0.7500000	
Angiospermae	1.0000000	0.8181818	0.9166667	0.6666667	0.3333333	0.7272727

Make the dendrogram 2: dendrogram



Summary

- Starting from **Pinopsida**, seed plants lost flagellate spermatozoa and micropylar chamber, and develop pollen tube
- Three genera of **Gnetopsida** are very divergent and morphologically close to angiosperms whereas molecular data place them close to conifers

Final question (3 points)

Final question (3 points)

Who is the most primitive seed plant? Why?

For Further Reading

J. E. Bidlack, Sh. H. Jansky.
Stern's introductory plant biology. 12th edition.
McGraw-Hill, 2011.
Chapter 22.

Th. L. Rost, M. G. Barbour, C. R. Stocking, T. M. Murphy.
Plant Biology. 2nd edition.
Thomson Brooks/Cole, 2006.
Chapter 24.